

165-125
XR AU 3743

(12) UK Patent Application (19) GB (11) 2 065 860 A

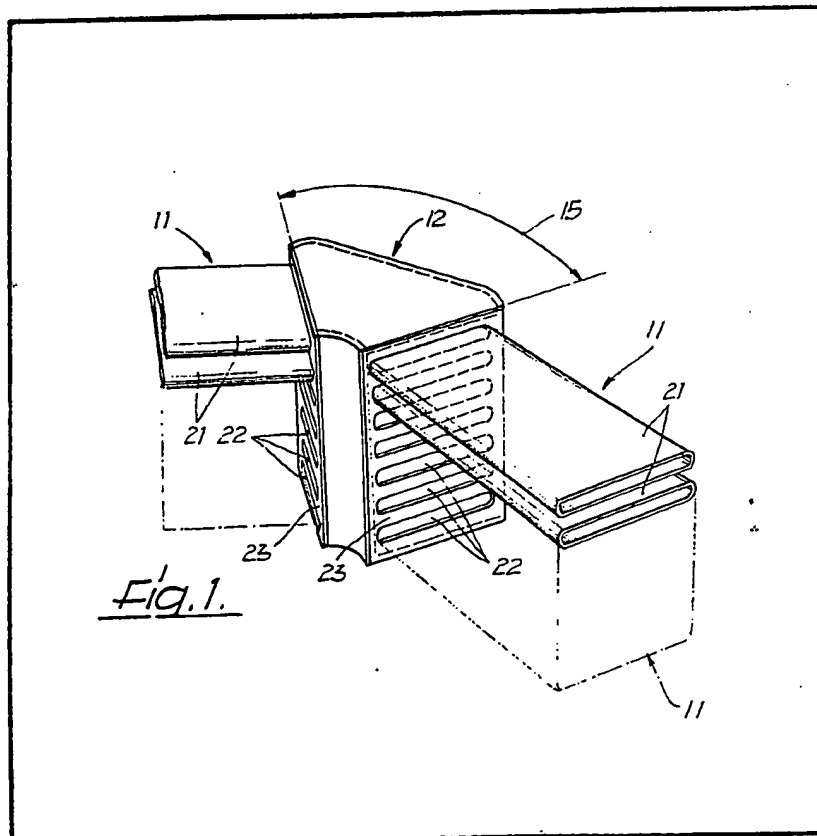
- (21) Application No 8008816
(22) Date of filing 14 Mar 1980
(30) Priority data
(31) 2951352
(32) 20 Dec 1979
(33) Fed. Rep. of Germany (DE)
(43) Application published
1 Jul 1981
(51) INT CL³
F28F 9/02 1/00 3/00
(52) Domestic classification
F4S 42C 4E1A 4F1 8
(56) Documents cited
GB 1489226
GB 898822
GB 819806
GB 572169
(58) Field of search
F4S
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(54) Flat Tube Heat Exchanger

(67) A heat exchanger (Fig. 1) has nests (11, 11) of straight, flat tubes (21) with their broad sides adjacent and spaced apart to provide intermediate spaces. One medium, for example oil, flows through the tubes, and another medium, for example cooling air, flows in the intermediate spaces across the tubes. To provide a

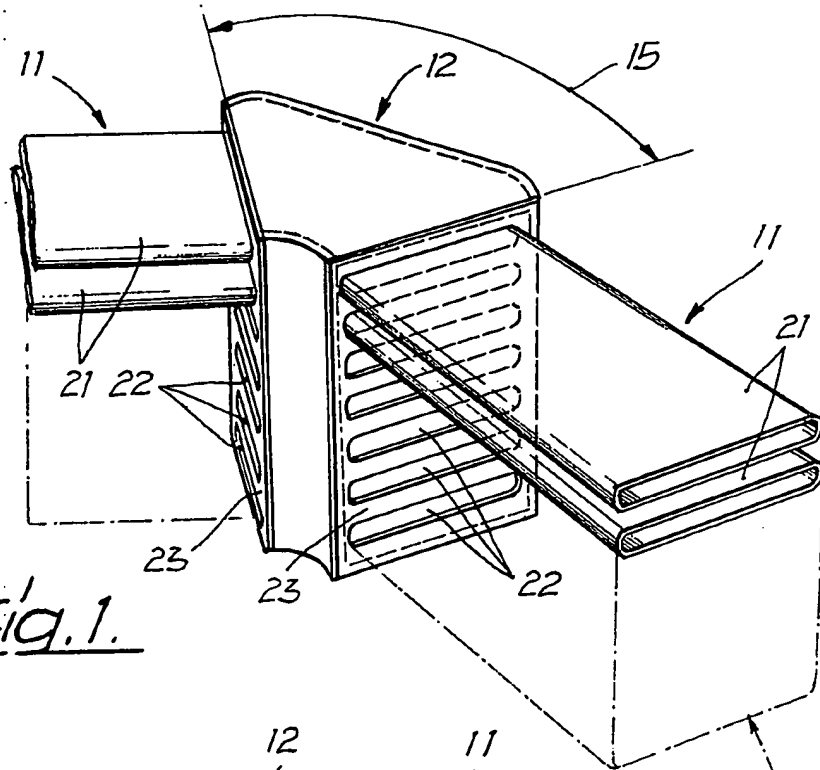
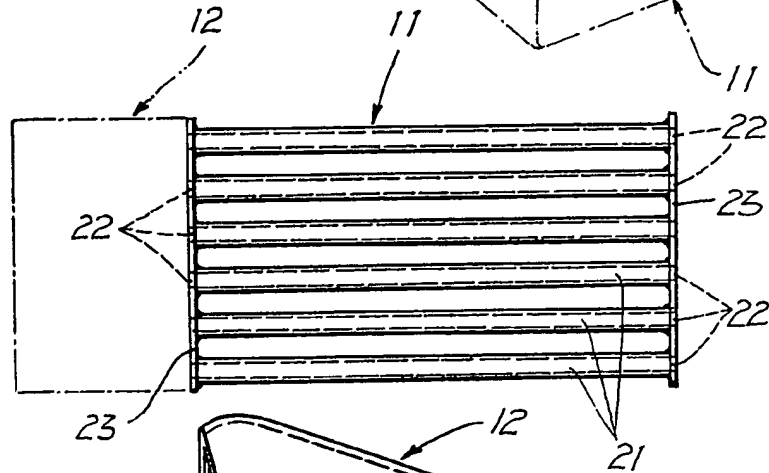
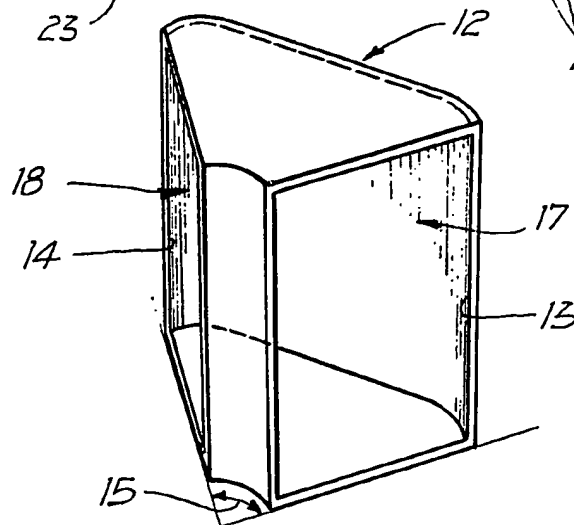
curved path (for instance an annular path) of flow of the one medium, yet using the straight, flat tubes, an angular connecting box (12) is used. Plates (23) with apertures (22) provide for connection of the nests of tubes to the angular connecting box. By the use of several such boxes and nests of tubes, an annular heat exchanger can be built up, with minimum waste of material during manufacture.

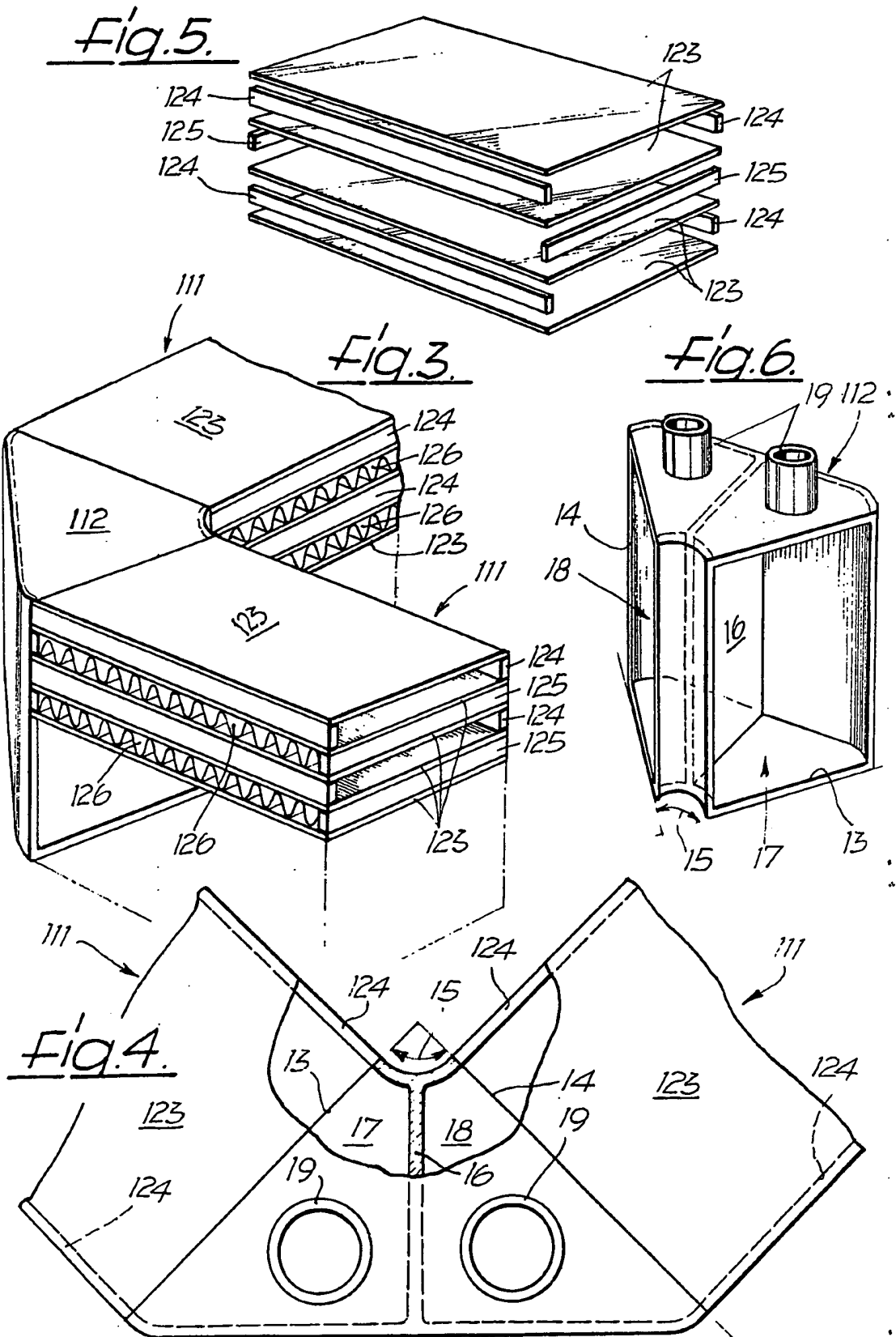
see Figs 7-10

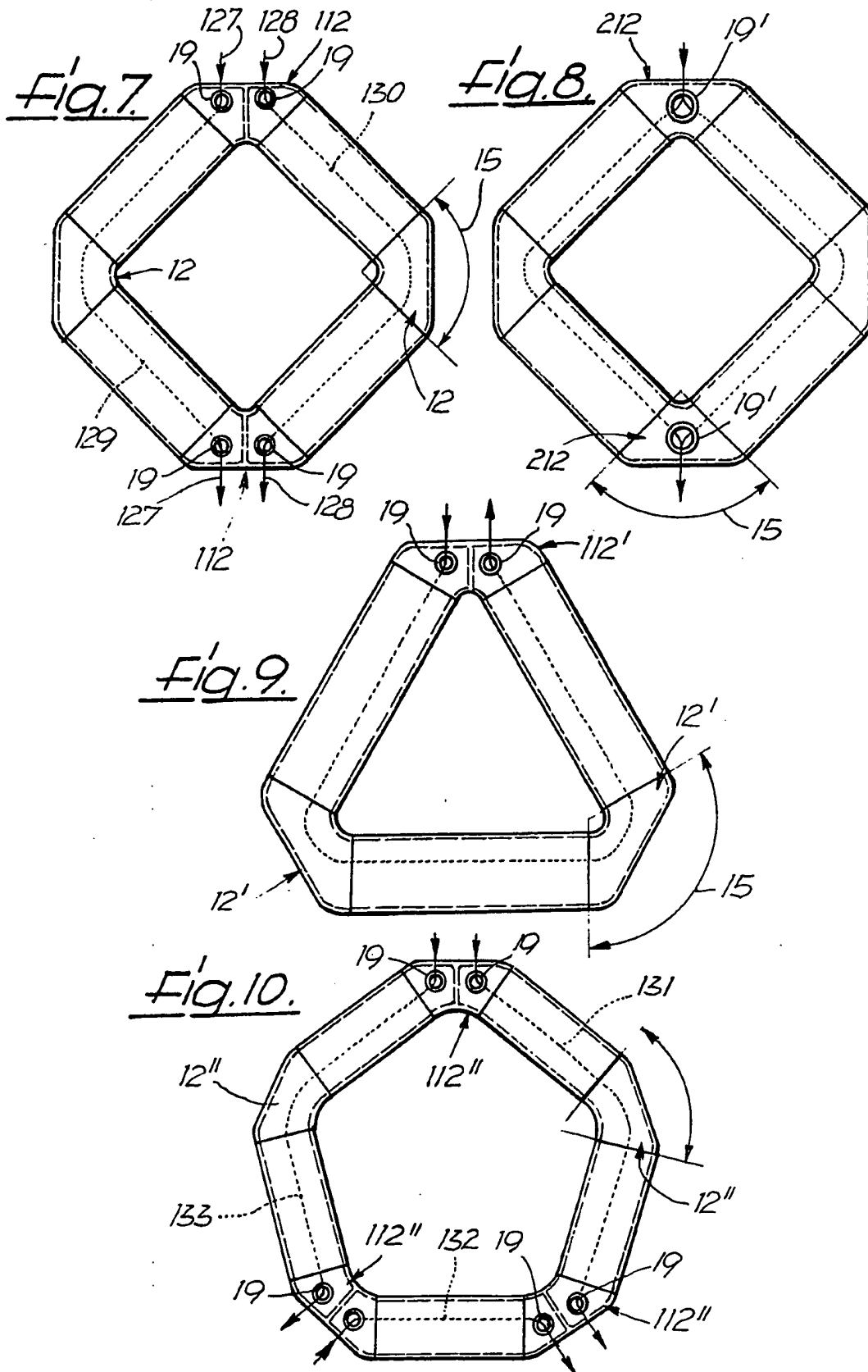


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Fig. 1.Fig. 2.Fig. 2a.





SPECIFICATION

Flat Tube Heat Exchanger

This invention relates to a heat exchanger, for example an oil cooler, having a nest of flat tubes having of equal length for throughflow of a first medium, for example oil, and which are assembled with their broad sides adjacent so as to form intermediate spaces for throughflow of a second medium, for example air, their adjacent ends being connected to form an end wall which outwardly closes off an aperture of a collecting box and through which the flat tubes discharge into a common collecting chamber of the box.

Such a heat exchanger is known from German Specification No. 21 13 583. The use of flat tubes in a heat exchanger has not only the advantage that heat exchanger is comparatively efficient, but that the heat exchanger has advantages from the production point of view. For example, a nest of flat tubes can be made up from rectangular plates which are connected, for example soldered, alternately at different oppositely disposed edges to strips which outwardly occlude the spaces located between the plates, so that throughflow spaces are formed which extend alternately in directions rotated through 90° in respect of one another. Such nests of flat tubes can, as is known, be produced easily in that solder-plated rectangular plates and corresponding strips are stacked one above another to form a nest and are then brazed to one another in a furnace.

Also nests in which the flat tubes are formed from welded or flat pressed seamless round-section tubes have particular advantages if it is desired to form corrosion-resistant heat exchangers. In such a case, the flat tubes can be produced from stainless steel.

In the known heat exchangers in which nests having welded or seamless flat tubes are used, the throughflow spaces extend through the flat tubes for the first medium in a straight direction. In practice however conditions may arise in which the first medium must flow over a curved path. Since these flat tubes cannot be curved about an axis at right-angles to their flattening, it is only possible in such cases to use flat tubes if they have been made from curved plates using strips bent into a curved shape, and in manufacture this causes considerable loss of material.

The invention is based on the problem of providing a heat exchanger with nests of flat tubes in which a curved throughflow path for a first medium is possible even when using straight flat tubes.

According to this invention there is provided a heat exchanger having nests of flat tubes for throughflow of medium, the tubes of a nest being of equal length and assembled with their broad sides adjacent so as to form intermediate spaces for flow of medium, their adjacent ends being connected to form an end wall wherein the collecting box has two apertures, each for connection to an end wall of a respective nest of flat tubes, through which end wall the tubes

discharge into the box, and which end wall closes off a respective aperture, and wherein the areas defined by the apertures are disposed at such an angle to each other that the collecting box constitutes an angular box, which so connects the two nests of flat tubes that the respective flow directions of the tubes of the two nests are at the said angle to one another. In consequence, two angularly disposed nests of flat tubes can be connected to one another by an angular box so that although the flat tubes are straight, the flow of the first medium can be deflected.

The angle between the two areas of aperture of the angular box may be $1/n$ of 360° and n identical nests of flat tubes may be connected to one another by n angular boxes to produce an annular heat exchanger having n sides. The invention thus provides the surprising possibility of producing an annular cooler from nests of straight flat tubes. An annular cooler of flat tube composition is known from German Specification No. 2,200,826. However, it consists of annularly cut-out plates which are connected by annularly bent strips to form the flat tubes for the first medium and by annularly bent sheet metal plates for forming the radially directed throughflow spaces for the second medium. When the annularly cut-out plates are produced, a considerable amount of material is lost in the cutting out operation. In contrast, in the heat exchanger of the invention, the flat tubes for an annular heat exchanger can be made from rectangular plates which are connected to one another by straight strips. Cutting of plates and strips to size is possible virtually without loss of material.

A further advantage of the heat exchanger of the invention is that, for an annular cooler, it is also possible to make up nests of flat tubes from welded or flap-pressed seamless circular section tubes, which may be of advantage particularly for special types of use, if the annular cooler has to be produced from a corrosion-resistant material, e.g. stainless steel.

For introduction of the first medium into and discharge thereof from the encircling flat tubes of an annular heat exchanger, two angular boxes may each be provided with an inlet and an outlet connection for the first medium, these connections being preferably disposed at diametrically opposed locations.

In a preferred embodiment, in at least one angular box there is associated with each of the two apertures a collecting chamber, the two collecting chambers being separated by an inner wall and being provided with in each case one connector for the first medium. As a result, an annular heat exchanger can be so designed that the first medium is introduced into one collecting chamber of the angular box and then flows through all the flat tubes of the annular heat exchanger to the other collecting chamber of the same angular box where it is then carried away through the discharge connection. It is possible also to use two or more such sub-divided angular

boxes so that then two or more throughflow spaces are available for two or more different first media. It is thus possible with a single annular heat exchanger and for example with a single second medium, for example air, to cool a plurality of different first media.

A further advantage is that simply by differing design of the annular boxes, namely by the choice of different fractions of 360° for the angle between the two aperture areas, it is possible to produce from identical nests of flat tubes annular heat exchangers of various sizes and thus with various annular diameters, which substantially simplifies the manufacture of heat exchangers or coolers of different sizes.

Embodiments of the invention will now be described by way of example, with reference to the drawings, in which:—

Fig. 1 is a perspective view of a first embodiment of a heat exchanger having two nests of pressed-flat seamless tubes;

Fig. 2 is a side elevation of a nest of flat tubes of the heat exchanger of Fig. 1;

Fig. 2a is a perspective view of the angular box used in the heat exchanger of Fig. 1;

Fig. 3 is a perspective view of a second embodiment having two nests of flat tubes;

Fig. 4 is a partly sectional and broken away plan of the heat exchanger of Fig. 3;

Fig. 5 is a perspective view showing the dismantled nest of flat tubes in the heat exchanger of Fig. 3;

Fig. 6 is a view corresponding to Fig. 2a but of an angular box having two collecting chambers;

Figs. 7 to 10 are plans of various annular heat exchangers constructed in accordance with the invention.

Referring to the drawings, the heat exchanger shown in Fig. 1 has two nests of flat tubes 11 which are connected by an angular box 12. The box 12 which is shown by itself in Fig. 2a has two apertures 13 and 14 each of which defines a plane area. These apertures are at an angle 15 to each other (Figs. 1 and 4) and are connected by the interior of the angular box.

The nest of flat tubes 11 comprises equal length, straight, flat tubes 21 constituted by flat-pressed seamless circular section tubes; they may be produced, for example in applications where corrosion is likely, from stainless steel or other non-corroding metal. The ends of the tubes 21 are connected, for example welded, to the edges of apertures 22 in each case a plate 23 so that the plates 23 disposed at both ends of the nest of flat tubes 11 form end walls of the nest of flat tubes. Each aperture 13 and 14 of the angular box 12 is occluded by such an end wall, formed by a plate 23, of a nest of flat tubes 11, which can be achieved for example in that the plate 23 is welded onto the edges of the appropriate aperture 13 or 14. The end wall which is left free can then be connected to a further angular box or to another collecting box. By the connection of the two nests of flat tubes by the annular box 12,

in spite of the straight throughflow spaces in the flat tubes, a curved throughflow path is provided for the first medium.

The embodiment of Figs. 1 and 2 can also form a part of an annular heat exchanger, as described below with reference to Figs. 7 to 12. Figs. 1 and 2 can therefore also be regarded as broken away views of a part of such an annular heat exchanger, the particular advantage of which, built up of nests of flat tubes 11, is that it can be produced from nests of pressed-flat seamless tubes of a corrosion-resistant metal, e.g. stainless steel.

The embodiment shown in Figs. 3 to 7 corresponds to the heat exchanger of Fig. 1, with the difference that each nest of flat tubes 111 is formed from mutually congruent rectangular plates 123 which are disposed in coincident relationship above one another and are spaced apart by strips 124 and 125, and are connected, for example soldered, to the strips. The strips 124 are in this case disposed along the longitudinal edges of the rectangular plates 123 so that two adjacent plates 123 and the longitudinal strips 124 in each case form, extending in the longitudinal direction of the rectangular plates 123, a flat tube which fulfils the function of a flat tube 21 of the embodiment of Fig. 1, for throughflow of a first medium, e.g. oil, into an oil cooler. The intermediate space formed by the gap between two flat tubes thus fabricated is laterally defined by two strips 125 which extend along the opposite short edges of the plates 123 where they are connected to the adjacent plates 123. These strips 125 and the plates connected to them define throughflow spaces whose direction of flow is at a right-angle to the direction of flow of the flat tubes, and which serve for flow of a second medium, e.g. air in an oil cooler. To improve heat transfer sheet metal plates 126 are disposed in the spaces extending along the strips 125, and these plates 126 may be soldered to the adjacent plates 123. Such a nest of flat tubes can be produced easily and virtually without cutting losses, in that the plates 123 and the strips 124 and 125, as shown in Fig. 5, are placed one above another. If the plates 123 and the strips 124 and 125 are solder plated, then in known manner it is necessary only for a nest of tubes which is thus assembled to be placed in a brazing furnace or a solder bath so that the parts can be brazed tightly together in one operation.

In a nest of flat tubes 111 soldered together in this way, the end walls are formed by the short edges of the plates 123, the ends of the strips 125 and the outer broad sides of the strips 125. These end walls can now simply be connected to the edges of the apertures 13 of angular boxes 112, being for example soldered together.

Figs. 7 to 10 show various annular heat exchangers made up from nests of flat tubes 11 or 111. In these annular heat exchangers, in addition to the angular box 12, an angular box 112 (Fig. 6) or 212 (Fig. 8) is also required. In the case of the angular box 112, the interior is subdivided by an inner wall 16 into two collecting

chambers 17 and 18, with which the apertures 13 and 14 are associated. Each collecting chamber 17, 18 has a connector 19. The angular box 212 like the angular box 12 has a continuous interior space and has a connector 19'. According to the size of the angle 15 formed by the two aperture areas of the angular boxes 12, 112, 212, so the number of sides of the many-sided annular heat exchanger can be varied at will.

- 10 In the embodiments of Figs. 7 and 8, the angle 15 is 90°. This results in a four-sided annular heat exchanger. In the embodiment of Fig. 7, two angular boxes 112 each have two collecting spaces and two connectors 19. These boxes 112 are at opposite corners of the annular heat exchanger or cooler. The two other angular boxes 12 each enclose a single continuous collecting chamber. As indicated in Fig. 7 by the arrows 127 and 128 as well as by the dotted flow lines 129, 20 130, this construction provides two throughflow spaces for the first medium which flows through the flat tubes. Such an annular heat exchanger can be used for a flow of a first medium, divided into two flows, or for two different first media.
- 25 The annular heat exchanger of Fig. 8 differs in that the two angular boxes 212 with connectors 19' have only one single throughflow space and thus only one connector 19'. This annular heat exchanger can be used only for a single medium flowing through the flat tubes, this medium, as shown by arrows and dotted lines in Fig. 8, being sub-divided into two branches which converge into one flow at the outlet connector 19'.

- 35 In the embodiment of Fig. 9, the apertures of the angular boxes 12' and 112' form an angle 15 of $360^\circ/3=120^\circ$. With these angular boxes 12' and 112', it is possible to build up a three-sided annular heat exchanger. In this embodiment, a single angular box 112' is sub-divided into the 40 two collecting chambers and has two connectors 19. The two other angular boxes 12' have a single chamber as a throughflow chamber. In this heat exchanger, the first medium flows through one connector 19 into the heat exchanger, circulates through the entire heat exchanger, and then flows out through the second connector 19.

- 45 The embodiment of Fig. 10 has two angular boxes 12' and three angular boxes 112'' in which the angle 15 between the apertures is 50 $360^\circ/5=72^\circ$. With these angular boxes it is possible to build up a five-sided heat exchanger. The three angular boxes 112'' are each sub-divided into two collecting chambers and each has two connectors 19, so that this heat 55 exchanger has three throughflow chambers 131, 132 and 133 and can be used for three different first media. In this respect, it must be remembered that the different throughflow chambers may be of different lengths in all 60 annular heat exchangers illustrated, according to where the angular boxes 112, 112' or 112'' are disposed. This has the advantage that in the use of different first media, different heat exchange conditions can be created for the media.

- 65 If, as is preferred, the annular heat exchangers are built up from the nests of flat tubes as shown in Figs. 3 and 5 then there results the surprising advantage that an annular heat exchanger can be built up from nests of flat tubes 111 which can be 70 produced virtually without loss of material in cutting the plates 123 and the strips 124 and 125 to size. A further advantage is that these nests of flat tubes 111, and also the nests of flat tubes 11 as shown in Figs. 1 and 2, can be used 75 for different sizes of annular heat exchanger, according to which angular boxes 12, 12', 12'', 112, 212, 112'' are used.

Claims

1. A heat exchanger having nests of flat tubes 80 for throughflow of medium, the tubes of a nest being of equal length and assembled with their broad sides adjacent so as to form intermediate spaces for flow of medium, their adjacent ends being connected to form an end wall wherein the 85 collecting box has two apertures, each for connection to an end wall of a respective nest of flat tubes, through which end wall the tubes discharge into the box, and which end wall closes off a respective aperture, and wherein the areas 90 defined by the apertures are disposed at such an angle to each other that the collecting box constitutes an angular box which so connects the two nests of flat tubes that the respective flow directions of the tubes of the two nests are at the 95 said angle to one another.

2. A heat exchanger according to claim 1 wherein the angle between the two areas of the angular box is $1/n$ of 360° , n like nests of flat tubes are connected to one another by n angular 100 boxes to form an n -sided annular heat exchanger.

3. A heat exchanger according to claim 1 or claim 2, wherein at least one angular box is provided with a connector for the first medium.

4. A heat exchanger according to any of claims 1 to 3, wherein in at least one angular box there is associated with each of the two apertures a collecting chamber, the two collecting chambers being separated by an inner wall and provided with each case one connector for the first 110 medium.

5. A heat exchanger according to claim 4, having at least two angular boxes which are sub-divided into two collecting chambers and form at least two throughflow spaces for one first 115 medium or at least two different first media.

6. A heat exchanger according to any preceding claim wherein the flat tubes of at least one nest are formed from rectangular plates which are alternately and at different oppositely 120 disposed edges connected by strips.

7. A heat exchanger according to claim 6 wherein the plates and strips are soldered together.

8. A heat exchanger according to any 125 preceding claim wherein the flat tubes of at least one nest are formed from welded or flat pressed

seamless circular section tubes, the ends of which are connected to the edges of apertures in a plate which forms an end wall of the nest.

9. A heat exchanger constructed and arranged substantially as herein described and shown in the drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.